S. HRG. 103–404

NASA's RELEVANCE TO THE U.S. ECONOMY

Y 4. C 73/7: S. HRG. 103-404

NASA's Relevance to the U.S. Econom...

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

OCTOBER 28, 1993

Printed for the use of the Committee on Commerce, Science, and Transportation

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NASA's RELEVANCE TO THE U.S. ECONOMY

THURSDAY, OCTOBER 28, 1993

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY,
AND SPACE OF THE COMMITTEE ON
COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:55 a.m., in room SR–253, Russell Senate Office Building, Hon. John D. Rockefeller IV (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: Elizabeth Inadomi, staff counsel; and Louis C. Whitsett, minority staff counsel.

OPENING STATEMENT OF SENATOR ROCKEFELLER

Senator ROCKEFELLER. I welcome all of you to this subcommittee's third hearing this year on NASA. Today we are examining NASA's contribution to the U.S. economy and to U.S. competitiveness. At our hearing in April Senator Burns and I focused on the NASA budget. I cited then an article which argued that our space program is no longer relevant to U.S. industrial competitiveness.

I am not prepared to agree with that judgment, but in light of the pressures that led Congress this summer to enact a budget with $500 billion of deficit reduction and to battle for real cuts in other Government spending in the recent appropriations bill, I believe it is this subcommittee's obligation to examine whether and how NASA's programs benefit the U.S. economy.

More specifically, this hearing is designed to explore if NASA, while meeting its own mission needs, is effectively and efficiently collaborating with American manufacturers in the development of important technologies. The question, of course, seeks the connection between investing in NASA and investing in economic growth and jobs for Americans.

As part of our effort to win the cold war, NASA was created in 1958 to ensure U.S. preeminence in aeronautics and space. In the postcold war era, with its diminished international threat to our national security, it is our country's international economic competitiveness that will increasingly guarantee our national well-being. It is therefore important that we in Government increase our focus, throughout Government, on international economic competition.

NASA, just as well as other agencies created to pursue technological missions, should be in a good position to adapt to these changes and help U.S. companies be more competitive. The jury is still out on whether that is happening.

With this change in national priorities, NASA needs to develop a comprehensive strategy that ensures its programs are specifically relevant to the increased importance of economic competition. In developing this strategy, NASA must look at its entire R&D program, in my judgment, not just the fraction that is currently devoted to the mechanism of technology transfer and innovation.

Equally important, NASA must assess its existing programs designed to help industry to determine whether the benefits are commensurate with the funding that NASA receives. For example, out of its $7.5 billion research and development budget, NASA will spend only $1 billion on aeronautics. I wonder if that is an appropriate allocation given the increased international competition faced by the U.S. aircraft industry?

NASA's long collaboration with U.S. aircraft manufacturers helped our country achieve leadership in aeronautics and contributed to a substantial trade surplus in this area. However, that leadership is now being severely challenged.

Most of the remaining R&D budget is directed to space projects. In this area, NASA's R&D funds have traditionally been used to develop highly specialized space hardware to fulfill its mission requirements. Unlike its work in aeronautics, NASA's space programs have not worked closely with industry in identifying and developing commercially useful technologies. Instead, it has established separate programs to spin off space technologies for possible commercial uses. Can we still afford the luxury of such single-use technology development programs, or can we increase the taxpayers' return on their investment in NASA?

In this fiscal year, NASA has been appropriated over $400 million for the programs it established to help U.S. industries use NASA's space technologies. Some of these programs have been funded since 1962. It is time to assess their real contributions to the U.S. economy.

An additional $113 million in R&D funding will be set aside in NASA for the Small Business Innovation Research Program. With the recent authorization of the SBIR program, the amount of money set aside in NASA's budget for small business research proposals will continue to increase. However, it appears that many in NASA view the SBIR initiative as a tax on its R&D program rather than an opportunity to encourage the development of technology that also has important commercial use.

Finally, for fiscal year 1994 NASA has allocated about $200 million for a new technology investment package aimed at fostering new aerospace technologies through partnerships with industry. Funded as part of other NASA program budgets, this investment package reflects NASA's desire to make some of its programs more relevant to U.S. competitiveness.

But I have to wonder whether creating another technology collaboration program within NASA is the best way to ensure that NASA is relevant to the U.S. economy, and these matters we will discuss. I think that making technology collaboration a central tenet of all NASA R&D programs and making technology innovation a central tenet of all NASA procurement programs may be better ways of increasing NASA's relevance to the U.S. economy.

Now these are some of the issues that the subcommittee will examine this morning, and I hope that the administration and NASA leadership share our interest in this line of inquiry. In this new era, in my judgment, we should all be open to changes that strengthen both the space program and our economy. Mr. Chairman, your comments, please.

OPENING STATEMENT OF SENATOR HOLLINGS

The CHAIRMAN. Today the committee is holding an important hearing on NASA's relevance to the economy. As the cold war has ended, U.S. investments in Federal research and development require a substantive reprioritization particularly in the face of budget constraints and aggressive international economic competition.

NASA and other mission-oriented agencies were created with a view toward missions that served the purposes of another time. No one argues that the Nation's priorities have changed dramatically since NASA was created in 1958. Today, the overwhelming focus is on Federal investment in the economy, and NASA must be examined in that context.

In fiscal year 1994, NASA will receive over $700 million, about 9 percent of its research and development budget, for new and ongoing programs created to develop technologies and assist U.S. industries. While it remains a question whether such programs are appropriate to support the Nation's competitiveness efforts, a larger concern is how NASA uses its entire research and development budget. Rather than simply adding more activities and requirements to NASA's agenda as a way of addressing economic priorities and U.S. technology competitiveness, we also need to examine carefully and reassess existing programs and budgets in the context of these changed priorities.

This hearing is an important contribution to this effort, and I look forward to the testimony of the witnesses.

Thank you, Mr. Chairman.

Senator ROCKEFELLER. Thank you, Mr. Chairman. Before proceeding with our witnesses, obviously I turn to my esteemed colleague and friend, Senator Burns, for any comments that he might have.

OPENING STATEMENT OF SENATOR BURNS

Senator BURNS. Thank you, Mr. Chairman, and thank you for holding these hearings today, which I think have a lot of relevance to our economy. This is a natural follow up to our Tuesday hearing on the technology transfer by our 700 Federal labs that are scattered around the country. The whole point of the hearing was that Government has to do a better job in following up and moving Federal R&D out of the labs and into the hands of industry who can convert those goods into a profitmaking process.

We face the same challenge with regard to NASA. Like our Federal lab system, NASA has a tremendous potential for technology transfer. Over the years, NASA space missions have generated a steady stream of commercial spinoffs in electronics, engineering, biomedicine, and other areas. Many technologies that we take for granted today, such as pacemakers, artificial limbs, water filtration

systems, communications satellites, all are byproducts of the space program.

It has been estimated that for every $1 invested in the space program, our economy has received $8 in the form of these other spinoffs. Most of these spinoffs were not the result of focused technology transfer programs in NASA, but evolved by chance when industry saw a commercial application for some NASA discovery. In today's world, however, tight budgets and our concerns about U.S. competitiveness require that we employ a more structured approach with regard to technology transfer.

But this does not mean the adoption of traditional Government technology transfer programs. At Tuesday's technology commercialization hearing, Dr. Good, the Department of Commerce's Under Secretary for Technology Policy, offered some helpful advice. Dr. Good referred to shifting our focus away from technology transfer and spinoffs and more toward precommercialization research and industry-Government partnerships, I think.

In other words, industry should be involved earlier on in the process, and that partnerships should be sealed before it is even put into use in Government projects. That having been said, I am aware of NASA's strong commitment to technology transfer in their network, through various industry-led grant programs, to pursue commercially relevant R&D.

So, I'm looking forward today to the testimony of Mr. Reck. And I want to welcome Dr. Good back this morning. And so I will be looking forward to what you have to say today, because I think Dr. Good hit upon a very worthwhile theme on her testimony last Tuesday, and I thank you for coming.

[The prepared statement of Senator Burns follows:]

PREPARED STATEMENT OF SENATOR BURNS

Mr. Chairman, I would like to thank you for holding this hearing on NASA's relevance to our economy. This is a natural follow-up to our Tuesday hearing on technology transfer by our 700 federal labs. The whole point of that hearing was that the government has to do a better job in moving federal R&D out of the labs and into the hands of industry who can convert it into goods and manufacturing processes.

We face the same challenge with regard to NASA. Like our federal lab system, NASA has tremendous potential for technology transfer. Over the years, NASA's space missions have generated a steady stream of commercial spinoffs in electronics, engineering, biomedicine, and other areas. Many technologies that we take for granted today—such as pacemakers, artificial limbs, advanced water filtration, and communications satellites—were all byproducts of our space program.

It has been estimated that, for every one dollar invested in the space program, our economy has received eight dollars in the form of these and other spinoffs. Most of these spinoffs were not the result of focused technology transfer programs at NASA but evolved, by chance, when industry saw a commercial application for some NASA discovery. In today's world, however, tight budgets and our concerns about U.S. competitiveness require that we employ a more structured approach with regard to technology transfer. But this does not necessarily mean the adoption of traditional government technology transfer programs.

At Tuesday's technology commercialization hearing, Dr. Mary Good, DOC's Undersecretary for Technology Policy, offered some helpful advice. Dr. Good referred to shifting our focus away from technology transfer and spinoffs and more towards precommercialization research and industry-government partnership. I personally believe that industry, not the government, must drive any successful effort to commercialize federal R&D. That having been said, I am aware of NASA's strong commitment to U.S. competitiveness through its Technology Transfer Network and through various industry-led grant programs to pursue commercially relevant R&D.

I am looking forward to hearing about the progress being made by NASA in commercializing its R&D.

Mr. Chairman, the central theme of this hearing is NASA's relevance to the economy. I think that one way NASA can help our economy is to explore new uses of existing federal facilities as our national needs change and evolve. For instance, DOE's principal MHD test facility is in Butte, Montana. MHD is a technology designed to convert coal-to electricity with minimal pollution. The federal government has invested over $200 million in this lab. It turns out that this technology has major non-energy applications in wind-tunnel testing and in spray metal casting. For this reason, the lab could, in the long run, make major contributions to the aerospace industry and U.S. competitiveness in manufacturing. Earlier this year, Administrator Goldin was kind enough to lead an on-site assessment of the lab. In this Senator's view, this is the kind of initiative that makes NASA more relevant to the economy.

Finally, Mr. Chairman, this hearing also gives the Subcommittee a chance to examine recent criticisms of two of NASA's commercial programs: the Spacehab program and the Centers for the Commercial Development of Space. Spacehab is a commercial venture that sells research space on the Shuttle, but, so far, its only real customer has been NASA. In recent weeks, NASA's Inspector General has asked NASA to give serious consideration to ending its support for the private Spacehab venture. In addition, an independent panel has recommended that NASA stop funding certain of the 17 Centers on the ground that many of the NASA funds are being spent on projects with little or no commercial potential. Hopefully, our witnesses will shed some light on these controversies.

Again, thank you, Mr. Chairman, for holding this hearing and I look forward to hearing from our distinguished panel of witnesses.

Senator ROCKEFELLER. And now, Secretary Good, we will start with you. And I would point out that you are Under Secretary for Technology Development in the Department of Commerce.

Mr. Gregory Reck will be next. He is Acting Associate Administrator for the Office of Advanced Concepts and Technology at NASA.

And Dr. Branscomb, who is a friend of many years and has done extraordinary work all over the country and all over the world and now is director of science and technology and public policy at the John F. Kennedy School of Government in Cambridge.

Dr. Good. And thank you for coming back again. I think you are an eager public servant.

STATEMENT OF HON. MARY LOWE GOOD, UNDER SECRETARY FOR TECHNOLOGY, DEPARTMENT OF COMMERCE

Dr. GOOD. Thank you.

Senator BURNS. She loves hearings.

Dr. GOOD. I like you fellas. It is OK. [Laughter.]

Thank you very much for having the opportunity to be here. I will tell you that the speech that I am going to give at about 12 noon, you will be pleased to know, is to the intellectual property lawyers. And we are going to further discuss those issues that we talked about on Tuesday, so I thought you would excuse me for trying to do that.

Senator ROCKEFELLER. That is good.

Dr. GOOD. Yes, we are going to try to start the discussion and the dialog that we discussed on Tuesday, which I think is very important to do.

Senator ROCKEFELLER. If you want to mention product liability and malpractice tort reform to them also, I would be grateful.

Senator BURNS. And, lawyers, our sympathies are with you.

Dr. GOOD. Yes, I think there is going to be something like about 400 of them, so you understand the odds.

Senator BURNS. Well, I understand them. That is about—let me see, you against 400, that is about even. [Laughter.]

Dr. GOOD. I am not going to comment on that, sir.

I have put together a written statement for today, and I will not read all of it in its entirety but I will try to make the highlights of what I would like to say, and I will leave the full text for the record, if that is OK.

Senator ROCKEFELLER. All of your statements are in the record.

Dr. GOOD. OK. First of all, I would simply like to remind us that for 35 years NASA has had a mission. They have had the real responsibility of solving problems for flight inside and outside the Earth's atmosphere, and for conducting the many different kinds of operations that are needed to explore space with manned and unmanned vehicles, and for working effectively with other nations that are engaged in peaceful space activities. They have provided the background that has helped us understand that we are not bound to this planet, and to gain a better understanding of the origin, the evolution, and the structure of our universe and the solar system.

Furthermore, as you pointed out, sir, in your opening remarks, its contributions to the development and growth of the aeronautics industry is really quite well known. And today our aeronautics is one of the largest industrial sectors in the country, and one of those that still has a significant positive balance of trade. Now, the question I think you ask is a very good one, because there are stresses on that system today, and how long that will remain is one of the issues that we need to talk about.

But we are, in the Department of Commerce, also very pleased that NASA appears to be in the process of dedicating itself to providing the kind of customer-based support for the space community that its aeronautics program has historically provided for the aviation community. Now, if it succeeds in this piece of its work, it does have the potential to bring enormous benefits to established space industries such as the satellite communications and the ELV's, growth industries such as remote sensing, and the emerging industries in microgravity materials.

Now, on the other hand, the Federal R&D establishment, of which NASA is such a prominent part, is undergoing considerable change. Not long ago Federal science and technology agencies could often justify their claims to a substantial share of Federal resources by stressing their glamorous results such as Moon landings or contributions to the world's storehouse of basic information. Commercial factors were, at best, secondary considerations.

Today, however, many of our institutions inside and outside the Government are finding that they can no longer remain ignorant of the harsh realities of the international competition as it exists today, and go on doing business as usual. Our Federal research and development establishment is under increasing pressure to demonstrate that it can work with industry to produce measurable, visible, tangible benefits to the taxpayers in the form of new or improved products, processes, and jobs.

So, accordingly, Mr. Chairman, I think it is laudable that this committee has undertaken this oversight and are beginning to look at the science agencies and to ask the kinds of hard questions that

you posed in your opening remarks. This new emphasis, there are really several reasons for it. It derives from a growing appreciation that the Federal interest in technology transcends such traditional Federal objectives of energy efficiency, improved health care, national security, mass transportation, environmental quality, improved agricultural yields, or a better understanding of the Earth's resources and how to manage them.

Now, in a time of constricted resources all of these, and many others, do remain vital concerns. But today we have a much greater appreciation of technology's potential for improving productivity, lowering costs, and yielding a steady stream of products and services. That is, we have a much greater appreciation of the role of technology as the generator of wealth and opportunity.

As other nations learn this truth—and many of them have already learned it already well—and adapt it to, so too must the United States adopt policies that will allow us to maximize the power of technology to enhance the competitiveness of the United States and the economic well-being of its people.

Second, the public's rightful insistence that we get our fiscal house in order means that we just cannot afford the luxury of spending without a clear understanding of what returns we expect, whether they are commercial or whether they are scientific and social in nature.

And third, there is a growing awareness that what worked in the past will not necessarily work in the future. The relentless pace of technological change puts a premium on getting to the market quickly with newer, better products. Yet we have paid insufficient attention to the commercialization, as distinguished from the creation of technology, assuming naively that breakthroughs in the laboratory will automatically be translated into new exciting products and processes.

Let me tell you from firsthand experience as a research scientist and a corporate research manager, there is no better prescription for failure than viewing the technology commercialization process as a relay race in which the athletes think they have done their job by running their lap and passing the baton off to someone else. The scientists in the lab cannot just toss some new product and prototype over the transom to the engineers to figure out what to do with it, who then toss it over the transom to the market staff who figure out how to sell it.

Today, successful firms are implementing models that fully integrate the research, manufacturing, and marketing components so that everybody has his eye on the prize and everybody can continually make meaningful contributions. Analysts have likened this not so much to a linear relay race, but to a basketball game in which the different players are constantly handing the ball off to each other as the entire team moves down the court.

The realization that change is needed is becoming evident not only in the way that firms organize internally, but in their relationships with other institutions, and this is where we come to the issues with NASA today. It often takes the forms of strategic alliances; consortia that share the risks and the skyrocketing costs of R&D; closer relationships between producers and their suppliers;

closer collaboration among businesses, academia, and the labor unions to ensure that our workforce has the training it needs.

There are probably many other types of collaboration, but I want to reinforce the one that is simply adaptation. Changing how one integrates the different parts of one's own business, uses one's employees, interacts with one's upstream and downstream components, and relates to other institutions is the key to survival.

Now, the need for change is at least as great within the Federal research establishment where until recently the laboratory culture has rarely accommodated commercial considerations and, in fact, has often been downright hostile to them. We can simply no longer rely on harvesting trickle-down applications of defense and other technologies to civilian industry.

Now, the Technology Administration in the Department of Commerce has a special responsibility to work with the Federal agencies to help them adapt their research programs and practices to this changing environment, and therefore to enhance the likelihood of successful technology commercialization. From that perspective, let me say that I can think of no Federal agency that has been more soul searching about the need to change the way it does business to better serve the needs of its customers through effective technology transfer than NASA has during the past year or two.

In a refreshing departure from the norm in Washington, NASA is one of the few agencies willing to acknowledge that some of its spinoffs, especially to the nonaerospace industries, have resulted more from effort and perseverance on the industry's part than from any outreach on NASA's part. NASA has openly recognized that it has to build technology commercialization into its programs from the ground up, and that it cannot assume that a notice saying "here's some technology we cooked up, come and get it," will get the desired results.

We are watching this NASA effort to change the way it does business with great interest and anticipation, not just because we are interested in how specific results may benefit specific industries, but also to determine whether NASA's methods for reinventing itself can be applied to and serve as a role model for some of the other agencies.

For example, we are particularly interested in the announced intention to build, through its advanced concepts and technology program, a dual-use focus into its activities, much as the Defense Department's Advanced Research Projects Agency is doing. This should enable NASA to pursue its research mission in a way that also contributes to other pressing national competitiveness goals.

If you look at some specifics, the Advanced Small Spacecraft Technology Program—which it will inaugurate this year—and its Industry Technology Program are clearly some of the issues that look very much—look very appropriate as a way to go. First of all, they have the potential to lead to cheaper and more frequent scientific and commercial space missions. But the collaborative issues, I think, are still important. And the issue is how to foster creation of industry-led integrated product development teams in these programs where we will get new ideas that will move very fast.

The Industry Technology Program was created and modeled after the Advanced Technology Program in Commerce, and like the ATP,

its focus, as I understand it, will be on precompetitive high-risk research of potential value to the aerospace and possibly other communities. Projects will be proposed by the industry, selection will be based on technical and business merit, and the industry will be expected to risk its own funds. We have program managers within the Department of Commerce and at ATP who will work with the NASA people so we can learn from each other and manage these programs so that they compliment and reinforce without overlapping.

Let me just pick two specific areas of activity that I think have potential to yield enormous benefits to the economy, where both we and NASA have special interest. One is the historic partnership with the automotive makers, that we discussed last week, for a new generation of vehicles that will be up to three times more fuel efficient than today.

If you look at that, the leapfrog technology, in particular I believe the NASA technologies have some real potential there. Because that kind of leapfrog technology normally comes from people who are looking at things differently than the people who have worked in the automotive technologies for such a long time.

So, here is an area where we think there are some real potentials for some collaboration and hopefully for some breakthrough. Because the NASA technologies run all the way from lightweight materials to high-temperature electronics, all of which could be very valuable in a next generation, noncombustion engine technology.

The issue here is to get direct collaboration with the industry and presently NASA has no contracts with the automotive companies. But this is an area where we can aid and abet that and do some stimulation that we think will be of importance. On the other hand, they have been one of the biggest pushers of fuel-cell technology, and they have some of the best technology in the Federal Government in fuel cells, and we think those are going to be important issues to look at.

Furthermore, I think with the aerospace clientele, that NASA is really beginning to explore cooperative agreements. Those groups, particularly in neuroprocessor technology for monitoring engine health, things like superplastic forming technology for low-cost aluminum parts, these are spinoffs, if you will, from some of the aerospace technology that has been done before. So, there are many areas where I think there are some real opportunities for collaboration.

The second one has to do with civil aviation. NASA is expanding its efforts in high-speed research, advanced subsonic technologies, and high-performance computing and communications. It is working with the industry on technologies required to make a high-speed civil transport economically and technically feasible. Such an aircraft could help us capture the valuable long haul Pacific Rim market. It is also accelerating investments in the important subsonic airliner sector, as this will remain a key element of both long haul and domestic air travel for the foreseeable future.

In sum, I think NASA's effort to reach beyond its usual constituency is entirely consistent with the fundamental principles of the current administration's national performance review; namely that agencies must do a better job of identifying their potential clients

and meeting their needs. I think in the effort to balance these traditional activities and these new outreach activities, it will bring more balance to the Government's technology strategy. A balance between basic research, which we still need and must support, and later stage research; greater balance between military and civilian technology; and greater balance between technology creation and commercialization.

So, let me just say in conclusion that there is a saying that says that if you do not know where you want to go, all maps are just as good as any others. To the extent that we can assist Administrator Goldin and his team in developing what I will call roadmaps for determining technology destinations and routes for reaching them, we will be delighted to do so. We have a very good working relationship with the NASA people and we hope to continue to have that type of collaboration across the agencies in the Government.

Thank you very much.

[The prepared statement of Dr. Good follows:]

PREPARED STATEMENT OF DR. MARY LOWE GOOD

Mr. Chairman and members of the Subcommittee, I am pleased to have been asked to participate in this important set of hearings on NASA and its relevance to the economy.

For more than thirty-five years NASA has been charged with the awesome responsibility of solving problems of flight inside and outside the Earth's atmosphere, for conducting the many different kinds of operations that are needed to explore space with manned and unmanned vehicles, and for working effectively with other nations that are engaged in peaceful space activities. It has helped us understand that we are not bound to this planet and to gain a better understanding of the origin, evolution and structure of our universe and solar system.

Its contributions to the development and growth of the aeronautics industry are well known and today aeronautics is one of the largest industrial sectors in the country. We are delighted that NASA is now preparing to dedicate itself to providing the kind of customer-based support for the space community that its aeronautics program has historically provided to the aviation community.

If NASA succeeds in this, it has the potential to bring enormous benefits to established space industries such as satellite communications and ELVs, growth industries such as remote sensing, and emerging industries such as microgravity materials processing and biotechnology products.

The federal R&D establishment of which NASA is such a prominent part is undergoing considerable change. Not long ago federal science and technology agencies could often justify their claims to a substantial share of federal resources by stressing their glamorous results, such as a moon landing, or contributions to the world's storehouse of basic scientific information. Commercial factors were at best secondary considerations.

Today, however, many of our institutions inside and outside Government are finding that they can no longer remain blissfully ignorant of the harsh realities of international competition as it exists today and go on doing business as usual. Today our federal R&D establishment is under increasing pressure to demonstrate that it can work with industry to produce measurable, visible, tangible benefits to the taxpayers in the form of new or improved products, processes and jobs. Accordingly, Mr. Chairman, I think it is laudable that committees such as this with important oversight responsibilities for the science agencies ask the hard questions that you are posing today.

Why this new emphasis? There are several reasons. First and foremost, Mr. Chairman, it derives from a growing appreciation that the federal interest in technology transcends such traditional federal objectives as energy efficiency, improved health care, national security, mass transportation, environmental quality, improved agricultural yields, or a better understanding of the earth's resources and how to manage them.

All of these, and many others, remain vital concerns. But today we have a much greater appreciation of technology's potential for improving productivity, lowering costs, and yielding a steady stream of products and services. That is, we have a

much greater appreciation of the role of technology as a generator of wealth and opportunity. As other nations learn this truth and adapt to it, so too must the United States adopt policies that will allow us to maximize the power of technology to enhance the competitiveness of the United States and the economic well-being of its people.

Second, the public's rightful insistence that we get our fiscal house in order means that we just cannot afford the luxury of spending without a clear understanding of what returns we expect.

And thirdly, there is the growing awareness that what worked in the past won't necessarily work in the future. The relentless pace of technological change puts a premium on getting to the market quickly with new or better products, yet we have paid insufficient attention to the commercialization, as distinguished from the creation, of technology, assuming naively that breakthroughs in the lab will automatically be translated into exciting new products and processes.

Let me tell you from firsthand experience both as a research scientist and as a corporate research manager that there is no better prescription for failure than viewing the technology commercialization process as a relay race in which the athletes think they have done their job by running their lap and passing the baton off to someone else.

The scientists in the lab cannot just toss some new prototype over the transom to the engineers to figure out what to do with it who then toss it over their transom to the market staff to figure out how to sell it. Today, successful firms are implementing models that fully integrate the research, manufacturing and marketing components so that everybody has his eye on the prize and everybody can continually make meaningful contributions. Analysts have likened this not so much to a linear relay race but to a basketball game in which the different players are constantly handing the ball off to each other as the entire team races downcourt to the basket.

The realization that change is needed is becoming evident not only in the way firms organize internally, but in their relationships with other institutions. This often takes the form of strategic alliances; consortia that share the risks and skyrocketing costs of R&D; closer relationships between producers and their suppliers; closer collaboration among business, academia, and labor unions to ensure that our workforce has the training it needs to remain the world's most productive.

There are probably many other types of collaboration I could cite, but the point I want to reinforce is simply that adaptation—changing how one integrates the different parts of ones own business, uses one's employees, interacts with one's upstream and downstream components, relates to other institutions—is the key to survival.

The need for change is at least as great within the federal research establishment where until recently the laboratory culture has rarely accommodated commercial considerations and has in fact often been downright hostile to them. We can simply no longer rely on harvesting trickle-down applications of defense and other technologies to civilian industry.

Commerce's Technology Administration has a special responsibility to work with federal agencies to help them adapt their research programs and practices to this changing environment and thereby to enhance the likelihood of successful technology commercialization. From that perspective, let me state unequivocally that I can think of no federal agency that has been more soul searching about the need to change the way it does business to better serve the needs of its customers through effective technology transfer than NASA has under Administrator Goldin's leadership.

In a refreshing departure from the norm in Washington, NASA is one of the few agencies willing to acknowledge that some of its spinoffs—especially to non-aerospace industries—has resulted more from effort and perseverance on industry's part than from any outreach on NASA's part. NASA has openly recognized that it has to build technology commercialization into its programs from the ground up, and that it cannot assume that a notice saying "Here's some technology we cooked up, come and get it" will get the desired results.

We in the Technology Administration will be watching NASA's effort to change the way it does business with great interest and anticipation, not just because we are interested in how specific results may benefit specific industries, but also to determine whether NASA's methods for reinventing itself can be applied to, and serve as a model for, other agencies.

We are particularly interested in the success of NASA's announced intention to build, through its Advanced Concepts and Technology Program, a dual-use focus into its activities, much as the Defense Department's Advanced Research Projects

Agency is doing. This should enable NASA to pursue its research mission in a way that also contributes to other pressing national competitiveness goals.

Of particular interest to us in that regard are NASA's Advanced Small Spacecraft Technology Program, which it will inaugurate this fiscal year, and its Industry Technology Program. The first is important because it has the potential to lead to cheaper and more frequent scientific and commercial space missions. However, consistent with the theme I struck a moment ago about the need for increased collaborative efforts, we are particularly interested in how well the Program succeeds in fostering the creation of industry-led Integrated Product Development Teams consisting of representatives of industry, academia, and small businesses to develop new ideas and concepts.

NASA's Industry Technology Program was created and modelled after Commerce's own Advanced Technology Program. Like the ATP, its focus will be on pre-competitive, high risk research of potential value to the aerospace and possibly other communities; projects will be proposed by industry; selection will be based on technical and business merit; and industry will be expected to risk its own funds. Our own program managers will be pleased to work with NASA so that we can learn from each other and manage our respective programs so that they complement and reinforce each other without overlapping.

I would like to note two specific areas of activity that have the potential to yield enormous benefits to the economy, where the Commerce Department has a special interest and responsibility, and where NASA will be expected to play a central role. One is of course the historic partnership which the Clinton-Gore Administration concluded with the U.S. auto makers to develop the technologies for a new generation of vehicles that will be up to three times more fuel efficient than today's.

Much of what NASA has developed through its own programs has the potential to be used by other sectors, such as the automotive industry. After all, its technologies run the gamut from lightweight materials to high temperature electronics. However, as I noted before and as NASA has itself acknowledged, it has not given high priority to working directly with industries outside the aerospace sector to enable them to adapt these technologies to their own commercial needs.

Thus, as I understand it, NASA currently has no contracts, cooperative agreements or Space Act agreements with automobile companies. Rather, its involvement has been largely indirect through programs such as the Department of Energy's Advanced Turbine Engine Program and DOE's Fuel Cells for Transportation Program.

However, I was delighted to learn that, consistent with NASA's effort to reinvent itself and to make its technologies adaptable by potential customers outside its traditional aerospace clientele, NASA is beginning to explore possible cooperative agreements with automotive companies in such areas as neuroprocessor technology for monitoring engine health, superplastic forming technology for low cost aluminum parts, lightweight batteries, power electronics for electric vehicles, abrasion resistant coatings for automobile polymeric windshields, and high temperature engine electronics.

The second area I want to stress relates to NASA's important efforts to strengthen civil aviation in the United States. NASA is expanding its efforts in high speed research, advanced subsonic technologies and high-performance computing and communications. For example, NASA is working with industry on technologies required to make a high speed civil transport economically and technically feasible. Such an aircraft could help us capture the valuable long-haul Pacific Rim market. It is also accelerating investments in the important subsonic airliner sector, as this will remain a key element of both long-haul and domestic air travel for the foreseeable future.

In sum, NASA's effort to reach beyond its usual constituency is entirely consistent with a fundamental principle of the Clinton-Gore Administration's National Performance Review—namely, that agencies must do a better job of identifying potential clients and meeting their needs.

Its efforts to balance its traditional activities and new outreach activities reflects the Clinton Administration's overall desire to bring more balance to the government's technology strategy—such as greater balance between basic research and later stage research, greater balance between military and civilian technology, and greater balance between technology creation and commercialization.

In conclusion, Mr. Chairman, there is a saying that if you don't know where you want to go, all maps are just as good. To the extent we can assist Administrator Goldin and his team in developing what I will call "roadmaps" for determining technology destinations and routes for reaching them, we shall be delighted to do so. We applaud NASA's commitment to making the goal of providing useful technology to industry a part of its overall mission and we look forward to providing NASA whatever assistance it may require.

Thank you. That concludes my statement.

Senator ROCKEFELLER. Thank you very much, Secretary Good.

You made in your statement an excellent analogy between NASA's method of technology transfer and a relay team. While successful firms approach technology commercialization like a basketball team, and that is the easy part, it is not obvious to me that if I handed a basketball to a good relay team that I would see a very good basketball game. Can the NASA sprinters play basketball?

Dr. GOOD. You are right, it is a difficult question. I think my view of that is the following. I really do have a firm belief and an optimistic view that people can change when they understand the necessity to. It is amazing how quickly people learn how to do things differently if the so-called wolf is at the door.

We do not do it very well in this country or elsewhere unless we really know that there is a real need to do it. It is my view that NASA today truly does understand that there are real issues here, and it is not business as usual. And under those circumstances, if you have bright people they can learn new games very quickly.

Senator ROCKEFELLER. Following on that do you think, therefore, that people of good will and earnest intent can when the mandates change in the world change budgets to reflect those mandates?

For example, in the R&D budget of NASA is it necessary, or simply desirable, or is it not necessary to change that budget to reflect chainging priorities?

Dr. GOOD. I think that the way that that has to happen is that—I think really my comments would be focused a little bit differently. And that is that my view is that budgets, all budgets, should be justified by what you are going to do with them.

And we understand, I think, what it is we want to do with at least a fairly sizable piece of the Federal R&D budget today. And unless the budget requests reflect that desire to get there and lay out how they are going to spend the money to get to those end results, then I think that you have to change the budgets.

But I think people should begin to understand that you really do have to put down where you are going and how you are going to get there, and how you are going to use the money. You have to do it. And you, in your capacity to review those, have to make good judgments as to whether those have been done in good faith and are they the appropriate way to go.

Senator ROCKEFELLER. I think it is interesting because I think that is going to be one of the debates in the health care budget, and I think it is a very proper debate, that unless you identify precisely what it is that you want to do in the case of health care, or a benefit package, or whatever, then it is very hard to put forward a meaningful budget, and therefore it is very hard to say, in this case, to the private and the public sector in health care that you are serious about what you are doing.

I think budgets have moral value as well as sort of general directional value.

Dr. GOOD. I agree with that, and I think budgets really are a tool to develop directions, to outline what you want to do, where you are going, to set these maps as to how you want to get there. I think that is what they should be used for.

Senator ROCKEFELLER. Let me ask you one more question. I am sort of asking you to be an inspector general for the U.S. Government here——

Dr. GOOD. I will not take total umbrage at that.

Senator ROCKEFELLER. NASA has nine field installations or research laboratories which carry out its R&D work, and they are located all around the country, and they have different strengths and weaknesses with regard to technology transfer and innovation.

I make a comparison. My wife is president and CEO of WETA public television and radio in Washington, and they are located in a dispersed area in Virginia. And they want to come together in a new facility at George Washington University because symbolically and in real terms to them if they are all in the same location and all in the same building—the concept of cross-fertilization of intellectual exchange, of programmatic exchange, creative exchange over lunch as well as in the elevators and the rest of it is really important.

Is there in R&D in NASA, therefore, any point in having disparate field research, nine different research facilities located around the country. Does that matter or does it not?

Dr. GOOD. Clearly it matters, and one has to understand how to work with it. You know, it is always difficult to answer a question like that because clearly if one would start green field today you would not necessarily build facilities and so forth like you built them 30 years ago for a different reason. On the other hand, if you have got investments in those and they are valuable, you also need not to throw away good facilities.

So, the issue I think is how do you, in today's world, utilize facilities that were designed for a different era but which do represent major investments and have major value in and of themselves.

Dr. Branscomb, who is sitting to my right, could expound on this much better than I, but the way we are going to have to handle that sort of thing without squandering those resources and investments is to truly understand and learn how to communicate quickly and fast with the new technology that is available today.

With the new technology that is available on the information highway, and the kinds of things that we can now do in simulation and so forth, and transmission of all of that, it really is possible to run a virtual laboratory with people working on the same problem and not being geographically sitting next to each other. We must learn to do that very quickly because we do have a big country. We have facilities all over.

This interaction between the laboratories and the industry—we have to really convert to what I consider to be virtual research groups where three or four of them are here, three or four of them are over there, but they are in total contact with each other, transmitting information all the time.

And if you do that well, it is perfectly feasible today to have people be wherever they need to be to use the facilities but still be a research or a development team in the real sense of the word. And that is what is going to be required to make these work.

Senator ROCKEFELLER. So, in a sense what you are saying is that just the nature of technology from E-mail on up and down makes

dispersion of a different magnitude than it would have been 10 years ago.

Dr. GOOD. That is absolutely correct. There still is no question that if you could have everybody sitting right beside each other, that is probably slightly better. But on the other hand, you do not want to lose the value of lots of investment in facilities and resources that we have spread around the country. And in today's world it really is possible to be geographically dispersed and still behave as if you were a single team.

Senator ROCKEFELLER. One final question from me, and then Senator Burns may have some. You said that you think that NASA can adapt and will adapt. NASA to some extent is an organization I would guess in some trauma because of what one might say is very firm leadership, diminution of staff, and several failures in mission. It has to be a difficult place at this point. And that is not faulting it, it is just simply people are people that way.

Now, you say that NASA can change its culture just because you believe that, particularly with respect to developing critical technologies while at the same time pursuing its traditional space mission. Just elaborate and make that more than a good faith statement. Where have you seen that done and why do you assume that will happen in a somewhat traumatized NASA?

Dr. GOOD. As you may know, I was a member of the blue ribbon panel to review the space station and the redoing of the space station. I was very impressed with the NASA people in the ability to really come back with what is a very, very different cultural approach to that project.

It was not easy. There was clearly a lot of trauma behind getting it done. But in the end they put together a plan which I think has a real shot at doing it well. And if you look at that plan it does not look anything like what the original situation was in terms of how they managed it, how they looked at the leadership, how the management was put together, and that group actually simply took it to heart and did it, and I think did a really very good job.

And in that interaction with them during that period of time there were some extremely bright and creative people who I just got to know in that process. And those people do know it is a different era, and they are willing to work differently from what they have done in the past.

It was not easy to do, and a shift of the magnitude is always hard, but I was very impressed with some of the talent, and if you give me options I would always go with where there is really first class talent.

Senator ROCKEFELLER. You know, I think I agree with you. I think it is a worthy bet, and I think I agree with you. Senator Burns.

Senator BURNS. I have no questions for Dr. Good. She has to have some time to prepare, and so I am going to allow her to do that. Thank you for coming. I appreciate your words.

Dr. GOOD. Thank you very much, and I really appreciate the opportunity to be here. Thank you very much.

Senator ROCKEFELLER. Thank you very, very much. Thank you a lot. Mr. Gregory Reck, can we go on with you now, sir, and Dr.

Lewis Branscomb, end up with you. We will just have one after the other and then questions for you both, please.

STATEMENT OF GREGORY RECK, ACTING ASSOCIATE ADMINISTRATOR FOR THE OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. RECK. Thank you very much. I really appreciate the opportunity to be here, and I also appreciate Dr. Good's comments. I think that she did a terrific job of capturing the environment and the attitudes within NASA today.

I want to take this time, just a few minutes here, to tell you how we are changing the way NASA does business in order to make the agency more relevant to the pressing needs of the country. I am going to try to summarize the statements that I prepared here, and I would like to submit my written statement for the record.

Clearly in today's times we face a number of challenges. Technological advances and their applications have been the engine behind U.S. productivity growth since World War II. However, the role of Government in technology is changing dramatically.

I believe that America's space program is a critical long-term investment in our Nation's future and can make a significant contribution to the international competitiveness of U.S. industries. But in order to keep the space program healthy as a mission agency, we must change the way we approach our programs and our technology transfer processes.

The Office of Advanced Concepts and Technology was established by Administrator Goldin last year to stimulate this change. We intend to lead the way, to foster innovation, and accelerate the use of new technologies. As a mission agency, I see our role in contributing to the Nation's competitiveness as having several parts. First, conducting dual-use technology development—where "dual use" means for NASA missions and also for commercial missions, providing support for both established and developing space industries, and then finally supporting the commercial space infrastructure needs.

The first area, dual-use technologies, represents a new way of doing business for NASA. Up until now, NASA's space technology program has focused on meeting NASA mission-specific needs first. Technology transfer to the private sector was also an objective but was not emphasized.

In a policy statement to all employees this past January, the NASA Administrator established that technology transfer is a fundamental mission of the agency, and to meet this commitment NASA will work cooperatively with a wide range of industries to identify opportunities and influence NASA's technology investments.

As an example of dual-use collaborations, NASA has developed expertise and capabilities across a wide range of space technologies from lightweight materials to compact power systems and controls. Much of this technology can be utilized by sectors such as the automobile industry. NASA is actively pursuing this route. For example, NASA is discussing jointly developing superplastic forming technology for the production of aluminum automotive parts. If we

are successful, we could make parts that are up to 30 percent lighter than current parts and offer savings to consumers in fuel costs.

Now, this represents real change for NASA. In the past, nonaerospace industries benefited from NASA more by their own efforts and their own perseverance than by NASA's commitment to serve them as a valued customer. Today, being commercially relevant is as important as being technically strong.

Two additional new programs in fiscal year 1994 that Dr. Good has already alluded to are further evidence of our commitment to dual-use technologies. The Industry Technology Program will use industry-led teams to develop and apply new technologies which meet the needs of aerospace and nonaerospace commercial sectors. Priorities for this effort will be established by industry and selection for proposals will be based on technical and business merit. This effort will be costshared by industry. Many features of this program have been patterned after the NIST Advanced Technology Program.

NASA is also an active participant in President Clinton's technology reinvestment project, which is led by ARPA and is geared to similar goals.

The other new fiscal 1994 program is the Advanced Small Spacecraft Technology Program to develop advanced miniaturization technology to greatly reduce the cost of space missions. This pioneering program will use industry-led integrated product development teams to define, plan, and implement the program, and these teams will include universities as well as small businesses.

The second major focus of NASA and OACT is to provide support for the commercial space community in a manner that is similar to the way NASA supports the aeronautics program and has provided support for the commercial aviation community. The commercial space community includes established industries such as satellite communications and ELV's, and also growth industries such as remote sensing and space processing.

The U.S. satellite communications industry is clearly an example of successful NASA-industry cooperation. The United States currently captures approximately 60 percent of the $8 billion worldwide market in satellite communications.

While the current worldwide market for remote sensing is small compared to this communications market, applications such as land management, environmental compliance, agriculture, and urban planning and development could increase this market by a factor of 10 or more in the next decade.

New and emerging industries in space processing use the microgravity in Earth orbit to produce thin film polymers, catalysts, semiconductors, and other products—NASA's role in these areas is to work with industry to identify innovative technologies to expand these markets, and support demonstrations of new systems and commercial applications.

To support all of these industrial sectors in 1985 we initiated an innovative program concept which has become known as the centers for the commercial development of space. The goal of this program is to establish partnerships among the Government, the private sector, and academic institutions to stimulate private sector participation in the commercialization of space.

We have recently completed an in-depth peer review of these centers, and although we will have to make some changes and some of the centers may not be continued, one of the central findings of the peer review is that this program has made a significant and effective start, and the concept of industry-Government-academic partnerships is key to the future of technology in the United States.

The third major focus of our Commercial Space Program has been to provide low-cost launch and access to space. We have initiated several programs to accomplish this goal, ranging from providing launch vehicles such as sounding rockets to the procurement of launch services such as the Commercial Experiment Transporter or COMET Program, and the commercial middeck augmentation module.

By using the space shuttle and expendable launch vehicles to provide commercial access to space, we hope to stimulate the U.S. commercial space research community by demonstrating that the space environment can be used to develop new and improved products.

The central thread underpinning our ability to ensure success in our technology transfer mission is the need to change the policies and the culture of NASA. Agency efforts to perform technology transfer have been hindered both by funding restrictions and also by an agency culture which has produced disincentives to considering such opportunities.

Senator ROCKEFELLER. How so?

Mr. RECK. Well, disincentives from the standpoint of how we reward employees. Pay raises and all of the ways that we handle employees have emphasized scientific goals and scientific missions. And I think the true test, the true question is when a research staff member receives a phone call from a private industry interested in a commercial technology and he is writing a paper for the next IAF conference, how is he going to decide to spend his time? Is he going to take 2 hours to work with the commercial community, with the small businessman trying to solve a problem, or is he going to think about adding to his list of credentials and papers in the community?

And I think if we are able to affect that decision to the point of this individual seeing a reward system and seeing the incentives in place to spend the time to work with the individual in the community on a commercial product and on an application, then we have really turned that corner.

Senator ROCKEFELLER. That is really the nub of it; is it not?

Mr. RECK. It is.

Senator ROCKEFELLER. In the sense that I was too instinctive in my approval of what Dr. Good said, that cultures change because cultures have to change, you are suggesting that people, like markets, have to have incentives and that until the incentives change people may understand that NASA is in a different era but they will not necessarily act differently if they have to pick from among 3 hours whether they are going to do technology work or NASA work. The incentives have to change.

Mr. RECK. Absolutely.

Senator ROCKEFELLER. And you were probably just about to answer that in your testimony, but is NASA actively considering how to do that now?

Mr. RECK. Yes, we are. We are looking at our promotion system. We are looking at the award systems that we have in place, how we provide raises, and looking at the criteria that we use for those rewards and those incentives. And once we determine how we want to effect those changes, then we need to communicate that to the employees and demonstrate it.

And I think as we begin that process, which takes time, and we are talking about changing a culture. We are talking about doing that all the way to the bottom. That takes time. But once we have done that, once we have made that change, then I think you will really see the proof in the pudding, as it were, here.

Senator ROCKEFELLER. And like in almost any other human behavior, you will have to show it and prove it several times over to get people to believe it.

Mr. RECK. Once you have established the metrics and the metrics really reflect what you want to accomplish, then you will see that take place. Too often we have made mistakes and we set the metrics in the level of activity and not the final product.

Senator ROCKEFELLER. Is this process for incentives, is that in process now or is that completed?

Mr. RECK. Yes, we have to make sure—as I suggested, we want to make sure we do it the right way. You can establish, with all the best intentions, the wrong incentives and end up stimulating the wrong kind of behavior. We have to make sure that we develop metrics that really measure what we want to produce.

Do we want to just generate cooperative agreements, or do we want to generate real products, new jobs, new sales markets, and revenues? And we have to make sure we understand and develop a way of measuring that sort of result, and use that result, then, demonstrably—use that result to reward people and develop the incentive program.

Senator ROCKEFELLER. I really think you are at the nub of it there, and I will stop interrupting you.

Mr. RECK. OK. Well, I just have a few more points. They do relate to the technology transfer activities. And I think the importance of this area is going to be emphasized and has been emphasized in the National Performance Review, where one of the specific recommendations does address technology transfer.

We are committed to making these institutional changes. And a centerpiece of these efforts will be a training program for our center employees in technology transfer, customer outreach, partnering techniques, legal aspects of partnership arrangements, and we are looking at our current system of incentives to see if new approaches can really make technology transfer a natural part of the way we do business.

In the coming year, all of our R&D activities, agencywide, are going to include plans for partnership arrangements with the commercial sector. NASA contracts, announcements of opportunity, will require a technology transfer plan for the commercial application of technologies that are being developed in those programs for NASA missions.

And the proposals that we receive in response to our solicitations will be evaluated on how, on those plans, the objectives would be achieved. And we are also going to expand beyond the NASA horizons and pursue and look for increased partnerships with State and local governments as part of the process.

The NASA Administrator will also grant each NASA center director and project manager more flexibility in funding technology transfer opportunities. And, just as important, will establish clear and sensible metrics to measure the results of these partnerships. The metrics will focus on such areas as new products to market and new jobs.

To give America the full sense of what NASA develops and the full use of what NASA develops, we must be more proactive in moving our technology into the general economy. The steps I have outlined will move us aggressively in this direction. After all, the true test of NASA as a jobs generator is not how many people are working for NASA or NASA contracts, rather it is how many people are working because of NASA; because of NASA's ability to reach out into the future to bring back the answers for today.

We represent the best that America has to offer, and our people have the will to make the changes necessary to influence our Nation's competitiveness. We are wholeheartedly dedicated to that purpose, and we look forward to working together with you to make it happen.

I thank you.

[The prepared statement of Mr. Reck follows:]

PREPARED STATEMENT OF GREGORY M. RECK

I want to thank you for the opportunity to appear before this Subcommittee today. I am here to tell you how the Advanced Concepts and Technology Program is changing the way NASA does business in order to make the agency more relevant to the pressing needs of the country. In today's times, we face a number of challenges. Technological advances and their applications have been the engine behind U.S. productivity growth since World War II. However, the role of government in technology policy is changing dramatically in the post-cold war era. The Nation's economic growth depends not only on commercial development of new technologies, but also the speed and efficiency with which our industrial sector applies these new technologies. I believe that America's space program is a critical long-term investment in our Nation's future and can make a significant contribution to the international competitiveness of U.S. industries. But in order to keep the space program healthy, change in how we, as a mission agency, approach our programs and our technology transfer processes is needed.

The Office of Advanced Concepts and Technology (OACT) was established by Administrator Dan Goldin in 1993 to stimulate this change by significantly improving the way NASA approaches the development and transfer of advanced technology as well as our concept of commercializing space and space technologies. We intend to lead the way in new programs and processes to leverage our research and development (R&D) resources to foster innovation and leverage to accelerate the development, commercialization and the use of new technologies. As a mission agency, I see our role in contributing to the Nation's competitiveness as having several parts: conducting dual-use (NASA and commercial industries) technology development, fostering technology infusion and commercial development for space industries, and supporting commercial space infrastructure needs. With this in mind, I would like to discuss some of the changes we plan and concrete steps we're taking to make this happen.

DUAL-USE TECHNOLOGIES: A NEW WAY OF DOING BUSINESS

Up until now, NASA's space technology program has focused on meeting NASA mission-specific needs first. Technology transfer to the private sector, although an objective of our program, was not emphasized as fundamental to accomplishing our

mission. Our goal now reflects a better understanding of the role NASA should—and can—play in contributing to the renewal of America's technological base and our Nation's competitiveness. The NASA Administrator is committed to making technology transfer a fundamental mission of the Agency. In the coming year, we will build technology transfer and commercialization into the fabric of NASA by requiring that our research be focused not only on the Agency's needs, but also on national needs. The President has established the requirement that NASA and all other federal R&D agencies devote 10-20 percent of their budgets to partnerships with industry. To meet this goal, NASA will work cooperatively with a wide range of industries to identify opportunities and influence NASA's technology investment strategies.

Let me give you some examples of the types of dual-use collaborations we are currently pursuing. As the leader of the national civil space program, NASA has developed highly recognized expertise and capabilities across a wide range of technologies from lightweight materials to high temperature electronics. Much of this technology can be utilized by sectors such as the automotive industry. NASA is actively pursuing this route. For example, NASA is discussing jointly developing superplastic forming technology for the production of aluminum automotive parts. Should this collaboration succeed, we could make parts that are up to 30 percent lighter than current parts and offer savings to consumers in fuel costs.

This represents real change for NASA. In the past our space technology program was focused mostly on NASA, and then the aerospace industry. Non-aerospace industries, such as the automobile, benefited from NASA more by their own efforts and perseverance than by NASAs commitment to serve them as a valued customer. This was not due to disinterest by NASA, but rather a response to the priorities of the time. The times have changed and so have NASA's priorities. Today being commercially relevant is as important as being technically strong. We are now working hard to change the way we conduct our programs so that we will accomplish our traditional space mission and make the maximum contribution to the U.S. economy and quality of life.

Two additional new programs in FY 1994, the Industry Technology Program and the Advanced Small Spacecraft Technology program, are further evidence of our renewed commitment to dual-use technologies. The Industry Technology Program will use industry-led teams to develop and apply new technologies which meet the needs of aerospace and non-aerospace commercial sectors. This program will focus on precompetitive technologies and innovative applications. it will support high-risk research and applications with strong potential for commercial benefits. Priorities for this effort will be established by industry and selection of proposals will be based on technical and business merit. A strong element of this effort will be cost-sharing by industry to ensure that they will have a vested interest in the success and timely commercialization of the projects.

The Advanced Small Spacecraft Technology program will develop and apply advanced miniaturization technology for spacecraft design and instrumentation to greatly reduce the cost of space missions. This pioneering program will be implemented by using industry-led Integrated Product Development (IPD) teams to define, plan, and implement the detailed program content. This will allow the integration of industry, universities, and small businesses into effective teams that fully develop the best ideas and concepts. The advancement of small spacecraft technology provides a mechanism to establish new opportunities in technology transfer for development of commercial products. We expect this program will greatly enhance the competitive position of the U.S. spacecraft industry in the international space market.

And, finally, OACT is an active participant in President Clinton's Technology Reinvestment Project which is specifically geared to similar goals. This program encouraged the creation of industry partnerships, focused on the application of dual use technology. We are part of the government team which includes the Advanced Research Projects Agency, the Department of Energy, the National Science Foundation, the Department of Transportation, and the Department of Commerce's National Institutes of Standards and Technology to foster partnerships which will bring federal technology to the marketplace.

TECHNOLOGY INFUSION AND COMMERCIAL DEVELOPMENT—AN EXPANDED OPPORTUNITY

The second major focus of OACT is to provide support for the commercial space community in a similar manner as the NASA aeronautics program is providing support for the aviation community. The aerospace market sector is significant, especially to a positive balance of trade. While it is dominated by aviation, space is a growing sector. In this context, the commercial space community can be separated

into three components: the established industries which include satellite communications and expendable launch vehicles; the growth industries which include remote sensing and Earth applications; and the new or emerging industries which include microgravity materials processing and biotechnology products.

In the sector of established commercial industries, the U.S. satellite communications industry is clearly an example of successful NASA-industry cooperation. The United States currently captures approximately 60 percent of the $8B world-wide market in satellite communications (including the launch systems for these satellites). However, the U.S. market share has steadily declined over several decades and investments in research and technology (R&T) by other countries have been growing. A recent study, "The NASA/National Science Foundation Panel Report on Satellite Communications Systems and Technology" provided a detailed analysis of the Nation's capabilities in key communications technologies compared to our international competitors. Building upon this study, we are developing a roadmap, in partnership with industry, for generic R&D and new approaches and applications which will meet the communications industry's needs. The recent launch of the Advanced Communications Technology Satellite (ACTS) illustrates one of NASA's strategic approaches with this community. ACTS is an experimental test bed bringing together industry, government, and academia to test and prove pioneering concepts and technologies that advance on-demand, flexible communications services to strengthen the U.S. economy in the 21st century. Over 80 experiments are currently scheduled with more expected over a two year period in application areas such as business communications and supercomputer networking, as well as technology verification and scientific research. These experiments will contribute to advances in education, science, medicine, and business opportunities. Our challenge in the coming years will be to develop new approaches to satellite communications, in partnerships with industry, in technology areas of highest commercial interest.

The second sector of growth industries includes remote sensing and earth applications. While the current world-wide market for remote sensing is approximately $800M (including launch, ground systems and services), growth in applications such as land management, environmental compliance, agriculture, urban planning and development, etc. could increase this market by a factor of 10 or more in the next decade. With this community, OACT's role is to work with industry to identify innovative technologies to expand this market and support demonstrations of new systems and commercial applications. NASA investments in this area include R&T in areas such as small satellite and instrument technologies, on-board processing, communications and artificial intelligence. NASA will work closely with the DOD and other government agencies with responsibilities in this area to support commercial activities.

New and emerging industries in space processing which utilize the unique attributes of space such as microgravity and/or high vacuum represent the greatest risk, but also potentially the greatest payoff. These products may include new or improved thin film polymers, catalysts, semiconductors, organic separations, protein crystals for pharmaceutical development, etc. We anticipate that some of these efforts will lead to commercial activities which may utilize the Space Station. The OACT role here is to stimulate and support the involvement of industry in these products and services and to provide access to the space environment for exploration and development.

To support all of these industrial sectors, we have initiated over the last several years, a number of innovative programs, such as the Centers for the Commercial Development of Space (CCDS). The CCDSs program was established in 1985 as partnerships among the government, the private sector, and academic institutions to facilitate private, non-aerospace entities' participation in the commercialization of space. Each Center leverages NASA dollars by working on promising commercial products. Although the CCDSs, as an aggregate, show significant progress towards the CCDS program goals and objectives, we have recently completed an indepth peer review to determine whether continued NASA support is warranted for individual CCDSs. Although some CCDSs may not be continued, one of the central findings of this peer review is that the concept of an industry-government-academic partnership is key to the future of technology in the United States.

We intend to pursue these types of innovative partnerships with industry as an effective tool in fostering the commercial development of space. For example, we recently established a pilot program to develop technology commercialization centers in conjunction with two NASA field centers. These "incubators" will couple NASA technology innovations with business skills and the venture capital community resources needed to establish new business ventures. We will also continue work under the Joint Sponsored Research Program. This is an innovative effort to conduct collaborative R&D projects between NASA, industry and universities to develop

dual-use technology that serves both NASA missions and commercial purposes. We will, however, ensure that clear transition plans are developed for each project area which establish completion criteria and define the transition to a commercial product development.

COMMERCIAL SPACE INFRASTRUCTURE NEEDS—A VITAL RESOURCE

A major focus of NASA's commercial space activities has been to provide low cost launch and access to space. We initiated several programs to accomplish this goal, ranging from provision of launch vehicles, such as sounding rockets to the procurement of launch services, such as the Commercial Experiment Transporter (COMET) and the Commercial Middeck Augmentation Module (CMAM). By using the Space Shuttle and expendable launch vehicles to provide commercial access to space, NASA hopes to stimulate U.S. commercial space research by demonstrating that the space environment can be used to develop new and improved products. The goal is to provide low cost access to space to conduct applied research in space in a number of high leverage areas, including: biotechnology to aid the pharmaceutical and biomedical communities in developing new products, services, and markets; and materials processing in space to aid in developing the next generation of super and semiconductors, special coatings and composites, polymers, alloys and new catalytic materials.

In addition to these programs, we continue to explore new ways to provide critically needed access to space to foster the exploitation of the unique attributes of space by U.S. industry. One such new approach is the launch voucher demonstration program which was developed in response to legislation which directed NASA to "establish a demonstration program to award vouchers for the payment of launch services and payload integration services." Since a program of this sort could not be developed without input from industry, an industry workshop was held July 20-21, 1993. According to industry, a viable voucher program would require from 1 to 3 orbital, or from 6 to 12 suborbital flights. After careful review of available payloads and resources, NASA plans to provide a total of 6 suborbital flights for the demonstration program. An implementation plan reflecting this program will be completed by the first of the year. with launches expected in 1995 and 1996.

CULTURE AND POLICY CHANGES

A central thread underpinning our ability to ensure success in our technology transfer mission is the need to change the policies and culture of NASA. Agency efforts to perform technology transfer have been hindered both by funding restrictions and by an Agency culture which has produced disincentives to consider such opportunities. I want to emphasize that NASA is committed to continuing the necessary institutional changes. A centerpiece of our efforts will be training for our center employees in technology transfer, customer outreach, partnering techniques and the legal aspects of agreement construction, rights and responsibilities. In addition, we are looking at our current system of incentives to see if new approaches would stimulate making technology transfer a natural part of the way we do business.

In the coming year, Agency-wide NASA R&D activities will include plans for partnership arrangements with the commercial sector. By collaborating with industry from the inception of a project, as we plan to do in our Advanced Small Spacecraft Technology and Industry Technology programs and as we have successfully done in our aeronautics initiatives, we will greatly increase the opportunities for the development of new products, processes and services. NASA contracts will clearly define a technology transfer plan for the commercial application of technologies developed for NASA missions. Additionally, NASA programs offered through the Announcement of Opportunity process will state that mission objectives also include technology advancement and infusion into the private sector and that grant proposals be evaluated on how such objectives will be achieved.

These efforts will help us build bridges, not only between NASA and industry, but also between the aerospace and non-aerospace markets. Our objective is to leverage our resources to benefit numerous sectors of the U.S. economy. As important, we will establish clear and sensible metrics to measure the results of these partnerships, metrics which will focus on such areas as new products to market and new jobs created.

The NASA Administrator also will grant each NASA Center Director and project manager more flexibility in funding technology transfer opportunities. Too often in the past, we have faltered in our technology transfer efforts as we bring a technology to the brink of success and then the money dries up. By identifying a pool of funds specifically for these ideas, we will be able to follow through and complete the job.

TECHNOLOGY TRANSFER—REVITALIZING OUR APPROACH

Finally, if we are to meet the President's challenge of redirecting our technology to enhance the competitiveness of U.S. industry, we must increase U.S. industry's access to commercially useful technology. We must create the appropriate internal and external structure to meet industry needs. The importance of this area has been emphasized by the recent National Performance Review (NPR) recommendation to improve the process of promoting, transferring, and commercializing NASA research and technology. We have put into place several initiatives to improve and streamline the Agency's technology transfer processes to be more responsive to national goals. Our goal for the coming year is clear. OACT will build upon and continually improve our current network for transferring technology while stimulating awareness and catalyzing the cultural change necessary to make technology transfer and commercialization the new way of doing business throughout NASA. (Our network consists of the National and Regional Technology Transfer Centers.) During the coming months, OACT will work with each office at NASA Headquarters and each NASA Field Center to assure that they develop explicit plans to push technology transfer higher on their agenda. And we will also expand beyond the NASA horizons and pursue increased partnerships with industry, universities, and state and local governments. We will ensure, through these partnerships that technologies developed by NASA and other federal government agencies are applied and adapted to provide new and enhanced commercial products and processes in areas such as manufacturing, energy, and health care. We believe our efforts in this area will be a critical and vital part of both NASA's and the Federal government's overall efforts to strengthen U.S. economic growth and industrial competitiveness.

Another important component of the Agency's commitment to leverage its resources to accelerate the development, commercialization and use of new technologies is the Small Business Innovation Research (SBIR) Program. This is a significant pool of funds since NASA ranked third in funds allocated to this program in FY 1993, with $99.6M for SBIR, behind the Departments of Defense and Health and Human Services. In FY 1994, consistent with new legislation, we intend to broaden the program scope and responsibilities to focus greater attention on the achievement of commercial applications of the federally funded research. Over the last year, a series of teams looked at ways we could improve the results of the SBIR program, making the proposals we select more relevant to the U.S. economy. As a result, we have taken steps to improve how we select projects and measure the commercial successes resulting from the funded projects. We also will initiate the Small Business Technology Transfer (STTR) pilot program designed to foster the transfer of technologies and to stimulate the commercial development, by small businesses, of new technology derived from universities, FFRDC's and non-profit research organizations.

CONCLUSION

To give America the full use of what NASA develops, we must be more proactive in moving our technology into the general economy. The steps I have outlined above will move us aggressively in this direction. After all, the true test of NASA as a jobs generator is not how many people are working for NASA or NASA contracts. Rather, it is how many people are working because of NASA—because of NASA's ability to reach out into the future to bring back the answers for today. We represent the best that America has to offer and our people have the will to make the changes necessary to influence our Nation's competitiveness. We are wholeheartedly dedicated to that purpose and look forward to working together with you to make it happen.

Senator ROCKEFELLER. Thank you very much, Mr. Reck.

Lew, I want to come to you now, and you may have this in your testimony or you may not. But, I would appreciate it if you would reflect on the following dilemma:

I was a Governor for 8 years, and we had 50,000 to 60,000 employees in State government. And there were a number of times when things clearly went wrong; where there would be kind of a very sustained effort on my part and people close to me and heads of agencies, and we would come together with urgency, with purpose, with full intent, and with full results, as far as we were concerned.

In other words, we had changed motivations, incentives, we had given clear new directions, and we had done it over a period of time—let us say, over 3 or 4 intense days of work, so we felt that that intensity would radiate out of the Governor's office and all over State government. And, of course, it does not. It just does not.

The people at the top are compelling in their intensity. And right now I am watching with great interest a dispute between the Department of Commerce and the Small Business Administration. And the Administrators of both places, the Secretary and the Administrator, are in full agreement and are both telling me that an agreement has been fully reached on something which in fact relates to this and is of enormous importance to me.

In the meantime, the bureaucrats, particularly on the SBA side, are proceeding as if their Administrator had not yet been appointed, each to protect their own turf, particularly on the SBA side.

I bring that up to the SBA Administrator, who is a superb administrator, superb, and is fully intending that this will work out. But the activity continues underneath. So, that is not incentive. I agree there is a difference between incentive and direction. But I am very interested in this sort of culture question. And I will not interrupt you.

STATEMENT OF LEWIS M. BRANSCOMB, DIRECTOR, SCIENCE, TECHNOLOGY AND PUBLIC POLICY PROGRAM, CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS, JOHN F. KENNEDY SCHOOL OF GOVERNMENT, HARVARD UNIVERSITY

Dr. BRANSCOMB. Thank you very much, Mr. Chairman.

Let me start by saying that I would be happy to sign my name to your opening statement. It suggests to me you must have been reading my book, "Beyond Spinoff." But I think you are absolutely on the right track. I am delighted with some of the new things NASA is doing and what Mr. Reck is involved in. I think those things are moving in the right direction.

They are, in a way, going on at the bottom of the Agency, because they are not really a feature of the main, central activities of NASA, and that is exactly what I want to talk about in this testimony.

I think the way things are in any part of our society, are that way for a reason. I have worked a lot on K through 12 school reform. If you ask why the schools are like they are—if you want to change them, the first thing you have got to figure out is why are they like that? Because if you change them, they will go back to the way they were unless you can change the driving forces.

And the core of my message about NASA is that the transfer of Government-generated technology to commercial firms, no matter how efficient the transfer might be, is not likely to be of much value unless the Agency has the mission, the management, and the money to create cutting-edge technologies of real value to commercial firms.

Years of bureaucratic encrustation, of indecisive leadership—and I am not talking about the current leadership, but some earlier—public disillusion with space adventures, and the erosion of NASA's commitment to technology development have taken their toll. We

have got to restore NASA or replace it as the creative engine for new technology.

Technology generation, in my view, has to become a central component of the NASA mission. The imbalance in NASA resources between the centers and their service contractors on the one side, and industry on the other, has to be reset to provide a larger fraction of NASA resources for contracts and grants in industry and in universities for technology and for missions.

And here I am simply borrowing from Norman Augustine's report of nearly 3 years ago now. His report noted that, if you calculate the percentage of the total NASA budget that is available to go out to contractors to do things, compared to what is in-house, you see there has been an erosion of capacity. And it is not because the civil servants are more numerous than they were. They are not. They are less numerous. But the number of service contractors and others in the centers have put a big concentration of activity in centers when, as Dr. Good points out, it would be of more benefit if it were out in industry and in the universities.

Now, in reality, we have two NASA's. And that is an advantage, it turns out. The operational NASA is primarily devoted to the conduct of space missions, primarily in three areas: the unmanned planetary programs, the Mission to Planet Earth, with its global change focus, and the manned flights of the shuttle, which anticipate the launching of a space station in the future.

The other NASA is a technological development and infrastructure support agency, working with aircraft manufacturers in the field of aeronautics and related areas of science. This part of NASA has a long, proud history in the NASA predecessor agency, the National Advisory Committee for Aeronautics.

The operational NASA buys technology for its missions in much the same way the Defense Department does, with many of the same barriers to commercialization. As documented in our book, spinoff from Government science is an often overrated mechanism for addressing U.S. industrial competitiveness.

It is noteworthy that if you compare the NASA technology utilization program of the past—I am not speaking of the new things NASA is doing—with the Department of Agriculture, which is kind of a model for how to do extension, Agriculture spends 50 percent of their R&D budget on extension services, on moving the technology out and helping the end user.

NASA spends less than 1 percent on that process.

In addition, agricultural R&D priorities are driven by countless meetings in granges all over the country. Agriculture has a bottom-up-driven requirements process, whereas the NASA technology is, quite understandably, driven by its space missions.

Now, there are lots of different ways that an agency like NASA could contribute to the economy through technology. And let me name five. The first is the provision of infrastructure, launch facilities, wind tunnels, tracking facilities, telemetry, et cetera, both for commercial space enterprises and for commercial aviation.

The second is the stimulation of a commercial space industry by lots of different devices, but, importantly, including procurement of the services and systems they can offer.

Third is the stimulation of nonspace, that is, Earthbound, commercial technology through procurement of components and subsystems for NASA use—often an underrated but very important mechanism for stimulating technology.

Fourth are R&D investments in dual-use technology in collaboration with industry, and the sponsorship of university research that leads to it.

And fifth is the transfer of technology from centers and from nonproprietary technology from contractors to commercial firms through technology utilization programs, including both document distribution services, cooperative research and development agreements, and the like.

It is my contention that the first four of these mechanisms are all more likely to be effective than the fifth. Many years ago there was a study done at NASA's expense by the Denver Research Institute, in which they were asked to go out into middle-sized, middle-technology industry and find out where these companies got their technical information.

The DRI had a list of 30 possible sources. The end result of the study was that the No. 1 source of technical information was from the technical sales rep of companies selling instruments, materials, hardware, and whatever. No. 2 was the technical sales literature and the trade journals.

Everything else was in the middle until you got to No. 30, and that was Government publications.

So, as Mary Good points out, technology transfer is a body contact sport.

Now, I want to focus on two areas. I am not going to talk about commercial space. I think that is very important and, in fact, the Hughes Satellite Corp. is one of the very few very good examples of a fully dual-use company. But I want to focus on two areas: the provision of industry infrastructure and technology services and the development, in collaboration with industry in the development of dual-use technology.

Any Government effort to enhance the technological capability in commercial firms must, in my opinion, meet three criteria. The first is the agency has to have as a major mission objective the creation of a range of high-value innovative technology.

In my view, the reason NASA is handicapped in doing this is that its major resources are spent on a dangerous and unacceptably expensive space shuttle. NASA should replace the shuttle with a technically modernized lift capability and a technology development mission for the revamped space station. The problem with the space station is we know we are not ready to go to Mars. There is, however, good reason for the country to think seriously about what it would take.

If we want to have a space station program aimed at space exploration, then we first should decide what the ultimate objective might be, and then we should ask, What are the set of technologies we need to master to find out whether that is a sensible thing to ever undertake?

The space station, then, should be motivated by some larger vision. But it should be designed in terms of what we need to learn and how we are going to learn it. And I do not believe that micro-

gravity either in biology or in manufacturing is an adequate justification for a program of this scale.

How did NASA get so far, as I am asserting it has gone, from focusing on developing of technologies as a central raison d'etre? And I believe there are two reasons.

And the first has to do with the budget process. All too often, the NASA comes into the Congress and says, "Here is our list of missions and here is the budget the President has authorized us to ask for." And the Congress says, "Well, what are you going to do if we do not have that much money?" And the Administrator says, "Well, I guess we will have to stop the program."

And so the Congress looks into its ouija board and decides it does not have that much money and comes up with somewhat less money. And then the agency says, "Well, somehow or other, we will make do." And the program does not get canceled.

Every time that happens some more technology gets stripped out, and you end up with a program of barebones operations, trying very hard to get by without an adequate technology investment.

The second explanation is something that happened right after the Apollo Program. I chaired the panel that wrote for the White House a set of three alternative post-Apollo missions for NASA. NASA came back and said, in the post-Apollo period, "Space is no longer a speculative, high-risk thing. We have done that now. We have proved that we have mastered space. From here on in, it is going to be conservative and we are only going to use proven technologies."

When the space shuttle was built in the early seventies, the only way you could bid for the computers that control it was to bid computers that had already flown in an existing avionics program. The original computers were 1967 vintage. NASA understood that was old stuff and, therefore, they designed fivefold redundancy with voting logic for this ancient technology.

It was only in the eighties——

Senator ROCKEFELLER. You mean they designed a backup system of that magnitude?

Dr. BRANSCOMB. What they did was put five obsolete computers in, and say, any time three of them have failed, we will scrub the mission. But so long as there are several of them giving us the same answer, they must be working.

Now, I was chief scientist of IBM when the Apollo Program was launched. And I went down and reviewed this, and I asked the people in Gaithersburg, "What did NASA give you for a mean-time-to-failure specification?" They said, "Funny you should ask, they refused to give us one." NASA said, "Why do you need a mean-time-to-failure spec, when we have five redundant computers?" And the IBM people said, "We do not know how to build a computer without a mean-time-to-failure specification."

So, finally, after much argument, NASA gave them a goal, not a specification. The IBM people doubled it, and said that is what they were going to build. But it was years and years before NASA finally agreed to let them update the hardware. It is still ancient architecture, because they want to keep the software, which has been widely tested.

I give that as only one example. I could give you other examples to show that, in the biggest programs in NASA—especially the shuttle—there has been very little new technology added.

The second requirement is that to be of economic value, the technology has to have some potential commercial as well as Government use. In other words, it needs to be dual use. In this case, not military and commercial, but space and commercial. The only way to ensure that is to engage a broad spectrum of commercial firms in the process of identifying exciting new technical opportunities and their joint development and funding.

The third thing is that the technology so generated has to be mastered by the commercial firms that are going to exploit it. That is very hard to do by transfers of technology from Government laboratories to industry. By far, the most effective means is to ensure that the technology is generated in the companies that are going to use it.

I am reminded of the fact that so many Government programs create technologies for the commercial sector in a process that Bob Frosh, who I believe will be testifying here next week, calls "chuck wagon" technology. It is sitting there on the back of the chuck wagon; "come and get it before we throw it out." This is not a very effective process.

I am delighted to hear from these other two witnesses that NASA has been working with NIST and is looking at the ATP program. Dr. Prabhakar is putting in place a new ATP program, in which there is an area of technology selected from among suggestions made by industry, and then specific projects are selected from among those, so there is some focus.

Clearly, NASA does not want to have a random ATP program. NASA's programs should be in space-related technology.

[The prepared statement of Dr. Branscomb follows:]

PREPARED STATEMENT OF LEWIS M. BRANSCOMB

I am honored to be invited to suggest how NASA might contribute more effectively to the technological capacity of American industry, and hence to economic performance. There is much that NASA can do. But the core of my message is that the transfer of government generated technology to commercial firms, no matter how efficient the transfer might be, is not likely to be of much value unless the agency has the mission, the management, and the money to create cutting edge technologies of real value to commercial firms. This is descriptive of the NASA we once knew but not the NASA of today. NASA is still staffed with many very fine scientists and engineers. But years of bureaucratic encrustation, of indecisive leadership, and of public disillusion with space adventures, and the erosion of NASA commitment to technology development have take their toll. NASA must be restored or replaced as a creative engine for new technology.

Twenty five years ago, in my capacity as chair of the Space Science and Technology Panel of President Johnson's Science Advisory Committee, I worked very closely with the NASA Apollo team. I watched the lift-off of Apollo 11 at Cape Canaveral and flew to NASA Houston for the moon landing. No technical achievement, before or since, comes close to the successful fulfillment of a truly national commitment to the manned exploration of the moon. Admittedly, Apollo was and still is "a hard act to follow." But many Americans, including me, are saddened by the doubts and confusion that surround NASA's mission goals, and above all by the general perception that NASA has lost much of the creative spirit and technical muscle that characterized NASA operations during the 1960s.

I will make some specific suggestions on how NASA might contribute more to the economic revitalization of American industry through collaborative work, but my central message is that first this steady decline in NASA's technological and operational muscle must be reversed. Technology generation must become a central com-

ponent of the NASA mission The imbalance in NASA resources between the Centers and their service contractors and the industry should be reset to provide a larger fraction of NASA resources for contracts and grants for technology and operational missions.[1]

There are, in reality, two NASAs with quite different traditions regarding mechanisms used to foster technology diffusion to industry:

1. The operational NASA is devoted primarily to the conduct of space missions primarily in three areas: the unmanned planetary programs, the Mission to Planet Earth with its global change focus, and the manned flights of the shuttle, anticipating the launching of a space station sometime in the future.

2. The other NASA is a technology development and infrastructure support agency, working with aircraft manufacturers in the field of aeronautics and related fields of science and engineering. This part of NASA's mission has a long and proud history in NASA's predecessor agency the National Advisory Committee on Aeronautics (NACA).

These two NASA cultures contribute to the U.S. industrial technology base in quite different ways. The operational NASA buys technology for its missions in much the same way the Department of Defense does, with many of the same barriers to its commercialization NASA has, in the past, emphasized spinoff—the commercial uses of government-developed technology—for this contribution. As documented in our book, Beyond Spinoff: Military and Commercial Technologies in a Changing World, spinoff from government science is an often overrated mechanism for addressing U.S. industrial competitiveness. The most highly advertised spinoffs from space exploration—Velcro, Tang, and Teflon—in fact all originated elsewhere.[2] It is noteworthy that the Department of Agriculture devotes half of its R&D budget to technology transfer; it's called agricultural extension. NASA historically devoted only one percent of its R&D to technology utilization. It is not surprising that the results were different, quite apart from the fact that the agriculture R&D priorities were driven by the needs of farmers, while NASA's technology is driven by its space missions.[3]

In fact, there are many mechanisms through which an agency like NASA could contribute to the economy. Some of them are:

1) Provision of infrastructure (launch facilities, wind-tunnels, tracking and telemetry, etc.) for commercial space and for commercial aviation.

2) Stimulation of commercial space ventures through procurement of their services and systems.

3) Stimulation of non-space, commercial technology through procurement of components and subsystems for NASA use.

4) R&D investments in dual-use (government and commercial) technology in collaboration with industry, and sponsorship of university research leading to it.

5) Transfers of NASA technology, from Centers and non-proprietary technology from contractors, to commercial firms through technology utilization programs, including both document distribution, Cooperative Research and Development Agreements, etc.

Most of the public discussion of NASA contributions to the economy have in the past focused on the fifth of these mechanisms, although the first four are much more likely to be effective.

I will not address NASA's relationships with the growth of a commercial space industry. One U.S. firm—Hughes Satellite—dominates the world civil telecommunications satellite market. However Defense, not NASA, is the major U.S. government customer of telesatcoms. Commercial space launch and space applications, other than telecommunications, are still infant industries. However much NASA helps this industry, or refrains from competing it, the economic effects will be small for some time.

I will focus on two areas: the provision of industry infrastructure and technology services and development, in collaboration with industry, of dual-use technology.

Any government effort to enhance the technological capability in commercial firms must meet three criteria:

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[1] In the new book from the Harvard project on technology policy we discussed the roles of the technical agencies of the federal government in the technological revitalization of U.S. industry. We said, "the National Aeronautical and Space Administration (NASA) is too narrowly focused and too constrained in mission and budget to be a major player, except in the field of aeronautics." L. M. Branscomb, ed., Empowering Technology: Implementing a U.S. Policy (Cambridge MA: MIT Press, June 1993), page 283.

[2] Beyond Spinoff: Military and Commercial Technologies in a Changing World, p. 55.

[3] J. Alic, L.M. Branscomb, H. Brooks, A. Carter and G. Epstein, Beyond Spinoff: Military and Commercial Technologies in a Changing World (Boston: Harvard Business School Press, 1992) pages 64–75.

1) The agency must have as a major mission objective the creation of a range of high value, innovative technology. This was clearly the case in the NASA we knew in the 1960s, when their missions all entailed substantial technological risk. Unless there is a bold plan to replace the dangerous and unacceptably expensive shuttle with a technically modernized lift capability and a technology development mission for the revamped space station, I do not see how one can expect much new technology of interest to commercial industry from these dominant NASA programs.

Today NASA's budget is stretched to the breaking point, and seems only enough to cover only its committed operations, with little left over for genuinely new technology. Too often NASA has told the Congress what it thinks is the bare minimum budget, below which it will have to cancel the program. When the Congress appropriates somewhat less than this minimum, the program is not canceled. NASA struggles on with less than enough to do the job right. Exciting new technology is the victim every time this budget ratchet effect occurs. Examination of the vintage of NASA technology in use will quickly reveal how old most of it is. The barriers to new technology injection in NASA's major programs—those involving manned space flight—are just as severe as they are in the Department of Defense. When this occurs NASA falls behind the state of the art of commercial industry, and the value of technology transfer drops again.

After the Apollo program, NASA shifted its technology strategy along very conservative lines. When NASA took bids on the Space Shuttle on board computers in the early 1970s they required that the technology must have been proven in prior avionics applications. Thus the computer technology IBM provided for the shuttle was 1967 vintage. NASA refused to give a mean-time-to-failure specification for these computers; instead they designed 5-fold redundancy into the system. It was not until the middle 1980s that NASA invested in newer technology computers. I was at IBM at the time, and I can assure you IBM learned nothing of commercial value from the contract to build these computers, which were obsolete when they were first used in the shuttle.

2) To be of economic value, the technology must have potential commercial as well as government uses; in other words it must be dual-use technology. The only way to ensure this is to engage a broad spectrum of commercial firms in the identification of exciting new technology opportunities and their joint development with shared funding.

This dual-use technology approach, which seeks to remove the barriers between dedicated defense firms and the commercial divisions in the same parent company, is the path being taken by the Department of Defense, and is even more appropriate for a civil agency like NASA. The Department of Energy does not run the nation's utilities or its fuels industry; it provides much of the non-proprietary technical knowledge base, however. There is no reason NASA cannot scale back its space operations commitments (primarily by moving off of the shuttle even if there is a multi-year hiatus in manned space flight and embarking on space station only after its technology goals are agreed) and generate enough room in the budget for broad investments in strong, light materials, in high performance computing, in new tools for software engineering, and in sophisticated guidance and control, all of which have terrestrial applications.

3) The technology so generated must be mastered by the commercial firms that will exploit it. This is exceedingly difficult to do through transfers of technology from government laboratories to industry, especially if the mechanism of transfer is through reports and other documents.

By far the most effective method is to ensure that the technology is generated and used a company that addresses both commercial and space markets. When technology development contracts are let, NASA should take into account the leverage that the contract might have in the non-space, commercial market. Thus the technology development programs I envision could be pursued through cooperative agreements for cost-shared, dual-use, technology development. NASA should examine the NIST ATP program for their experience in this kind of cost shared technology development, especially under the new policies that Dr. Prabhakar is introducing in which several strategic industry areas will be identified for focused, shared investment.

NASA can learn a lot from its own NACA tradition. The NACA mission was not an operational one, but rather was dedicated to building infrastructure of knowledge and test facilities needed to support the rapid development of the U.S. airplane industry for both civil and military purposes. NACA was the prototype of the dual-use technology agency. Historians who have studied the record find that NACA was enormously influential in the period between the wars. That was a period of very exciting technical progress and industry growth. Today the civil aviation industry

is maturing and the airforce has moved into very sophisticated, stealth aircraft, for which there is little commercial equivalence.

Nevertheless, there are opportunities today that may be more critical to the airframe industry than ever, for the commercial aviation industry—while the best contributor to export earnings in the manufacturing sector—has come down to two commercial transport manufacturers and a very few general aviation aircraft producers. The stakes are much higher than they were in the 1920s and 1930s, when the industry was small. And technical change is still rapid in the industry, but it is not so visible, since primary targets for new technology are reliability, safety, and economy. However there are many elements of the industry infrastructure where government help is needed and is appropriate.

I am told by Boeing engineers that there is no wind tunnel of such size and capability sufficient to support the next generation of commercial transport aircraft. The capital cost of this facility is more than even a firm of Boeing's size cannot afford. Here there seems all obvious opportunity for the Air Force, NASA and the industry to undertake to construct a shared facility.

Another dual-use technology for NASA investment is the application of high performance computing to design, simulation and modelling of aircraft. NASA has been a contributor in this field, but does not have anything like the resources to invest that are available to the Defense Department's Advanced Research Projects Agency (ARPA) and the National Science Foundation. Other examples might include advanced structural materials, nondestructive testing, dynamical control of vibration and acoustic noise.

I am told that in earlier days the Langley Center, which is once of the NACA aeronautics laboratories, was jokingly called "Boeing East" because of the close technical collaboration NASA Langley enjoyed with Boeing engineers. That collaboration should be fostered so that the industry not only has access to NASA developments, but has a substantial influence in the laboratory's technical agenda.

The full technical scope of NASA is, of course, much broader than aeronautics. The technologies required for the planetary, astronomy, and earth observing missions cover a very broad range of materials, electronics, optics, energy, communications, guidance, and control technologies. What stands in the way of NASA making investments in commercial firms that can develop those technologies for their own commercial markets and for NASA use?

Norman Augustine identified one such barrier in his analysis of changes needed in NASA.[4] The fraction of NASA's budget that is spent in-house has steadily grown at the expense of the outside contractors. This is not so much a consequence of growth in the number of government employees in the Centers as the growth of service contractors there. In addition, the program management responsibilities are highly fragmented, so almost every Center has some role in almost all NASA programs. This creates inefficiency and the need for excessive amounts of coordination. If the Congress wants NASA to contribute to industry's technological muscle, it must put a much larger fraction of the resource into developing the technology in industry. It should also encourage those firms to exploit the technology they develop in collaboration with industry in their commercial markets. NASA should look carefully at the NIST ATP program and see if a similar activity focused on technologies within NASA's mission scope would not be an excellent way to create capabilities for future NASA missions.

Last week the Congress abandoned the Superconducting Supercollider. This is not the time or place to review the meaning of this decision, except to note that many leading scientists, when asked to comment on this event, said "I wish it had been the space station instead." My message is that NASA has to create a mission that is affordable and allows big leaps in technology for its achievement. Biology experiments and space manufacturing in zero gravity offer neither the scientific knowledge return nor the technical challenge to engage the best talents in industry and universities.

Many years ago when the physicist R.R. Wilson was testifying for the Fermilab accelerator, he was asked by Senator Pastore, "What will this machine do for our national defense?" "Senator," Prof. Wilson replied, "It will do nothing for our national defense, but it will do a lot to help make our country worth defending." The central issue facing NASA and its contribution to the nation's economy and technological capacity is the restoration of a strong mission to create and employ in highly worthwhile endeavors a portfolio of new technologies of broad application, in space and on earth.

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[4] See L.M. Branscomb testimony to the House of Representatives Committee on Science, Space, and Technology hearing on the Augustine Report, January, 1991.

Senator ROCKEFELLER. OK. This is spectacular. It is iconoclastic, but not so when it comes from you. Because you have just historic perspective on all kinds of things in this country. And I really value that.

In a sense, then, do you say that NASA's technology spinoffs, in terms of their return to the U.S. taxpayers, have not been reasonable and are not reasonable at this point?

Dr. BRANSCOMB. I think in past history NASA's mission was in fact to demonstrate American capability to operate in space in an enormously impressive way. And they have done that. It was not to create technology. And the spinoff message from NASA has really been, this is a marginal and supplementary activity that we do, that we think is handy. But when you are evaluating spinoff, you have to ask—if you want to know how valuable it is—"compared to what"?

Is 100 million dollars' worth of spinoff valuable? Of course it is.

If you are spending $7 billion to get it, is there a better way to get 100 million dollars' worth of spinoff? You bet there is, if you did not have to do anything else.

So, I think, in fact, that if NASA looks to the experience of the NACA, and Langley Laboratory is called Boeing East for good reason, it will find the mechanism is well known.

I think that tradition, from the NACA, was a tradition in which the NACA people developed facilities, they developed materials, they developed design methodologies, and other enabling technologies that were designed in collaboration with people in the airframe industry who had a clear understanding of what would be helpful.

And it really was a collaborative activity. It still is. But historians would give the period between the two World Wars as the glory period of that operation.

That, I think, is the mechanism that should be used in the larger part of the NASA program, as well.

Senator ROCKEFELLER. Lew, you are suggesting that incentives will help, but there has to be more. You are suggesting that culture is very difficult to transform. So that we have three mechanisms.

We have what takes place inside of NASA after budgets and directions have been given, which is incentives, and then internal direction and the triumph over a bureaucracy. Second, we have budgets which stipulate concentrations. And, thirdly, we have the so-called direction, which is provided by the President. He wants more technology transfer, commercialization results from NASA, and what Dan Goldin does.

Would you describe how this process will come to be effective in NASA, or can it be, with those three factors at work?

Dr. BRANSCOMB. My summary of that is that the three issues are mission, management, and money. And at the heart and soul of it is mission. NASA needs a clear, compelling mission that the President is behind and the Congress is behind and the people are behind. In my view, that mission should be defined so that there is enough money to do it with great technological cleverness. So, there is real intellectual benefit that comes out of it. It should not be stretched to the breaking point.

Then I think NASA can manage to that new mission. It has a lot of management improvement to do. But I think that is fairly straightforward. And I think the culture will change once the mission is understood and the budget is appropriate to the mission.

Senator ROCKEFELLER. But the budget has to reflect the mission?

Dr. BRANSCOMB. The budget has to reflect the mission.

Senator ROCKEFELLER. And does not at this point?

Dr. BRANSCOMB. If you compare NASA and—the Department of Energy, goodness knows, has at least as many problems, if not more, than NASA has. But it is different in the sense that it really does have technology mission that is clear. Because, in its area of industry, the operational responsibility is all in the private sector.

NASA clearly needs to move in that direction.

Senator ROCKEFELLER. Now, when you say move in that direction, toward the private sector, by doing?

Dr. BRANSCOMB. By cutting back, if we can find a way to do it, on the most expensive part of the NASA program that has the least clear benefits to the American society; and putting the investment into both the encouragement of the commercial and civil side of space; and recognizing that its remaining space operations, which are very important, draw on every kind of technology the country has; that most of that is dual-use technology. And if it is developed in collaboration with industry and not relying primarily on the in-house centers, it will bring more benefit to the economy.

Senator ROCKEFELLER. Mr. Reck.

Mr. RECK. Yes. Well, from the standpoint of mission, management, and money, I think we are all in violent agreement that those are all three absolutely essential, critical factors in this process.

From the standpoint of mission, we are working very hard to develop a very concise statement that will capture all of the aspects of what NASA does in terms of exploring space, generating knowledge, translating benefits here to us on Earth, understanding Earth, and so forth.

One thing is clear, and that is that the Administrator intends that the mission incorporate the commercialization of NASA technologies as an essential feature. And he has made that statement clear on a number of occasions.

And so, from the standpoint of missions, we are working and laboring very hard to craft a statement that will capture that, with the emphasis that he really wants to put on it.

Senator ROCKEFELLER. But are you suggesting, Lew, that a statement from—a mission from the director is not the same as a mission as mandated by Congress, through its budget process and by the President through oversight and so on?

Dr. BRANSCOMB. Yes, I am suggesting that the current full-spectrum program in NASA, including the space shuttle and the space station, as well as the very important Mission to Planet Earth and the Planetary Science Program, and the technology investments, NASA is not funded to do all that adequately. I really worry about the space shuttle.

NASA's own numbers, and those of the OTA, suggest that the risk of catastrophic failure is something like 1 in 100.

I do not think that we have such entirely compelling reasons to keep running a manned space program until we are able to use it as a vehicle for creating technological capability that is of demonstrable value. And that if we had to take a hiatus in manned space flight, maybe we should bite the bullet and do that.

And I am not suggesting that Mr. Goldin is going to be the man to volunteer to do that.

Senator ROCKEFELLER. No.

Dr. BRANSCOMB. I think that has got to be a national consensus decision.

Senator ROCKEFELLER. You are suggesting some absence of congressional leadership.

Dr. BRANSCOMB. Some fairly deep long-range planning is really needed, looking realistically at the budgets. I worry about the precedent set by the supercollider. I do not want to see NASA go down the tubes with the same logic.

Senator ROCKEFELLER. Mr. Reck, you are going to have to have the last word.

And I apologize to you both.

Mr. RECK. OK. Well, I appreciate the opportunity.

The mission statement I think is a beginning; that is not the end. The mission statement then has to be translated into budget and priorities. And all of the components that we incorporate have to be assessed from the standpoint of their relevance to our national needs. And the economy is certainly of paramount importance among those.

And I am sure that we are going to get the advice of Congress and the support of Congress in setting those priorities. Certain parts of the NASA program clearly relate more closely and can provide more dual-use applications than others. And so we are going to have to emphasize those in that area.

Senator ROCKEFELLER. If you could close it right away. I have got 4 minutes or else I will miss the vote. We will continue this on paper. Four minutes more here; go ahead.

Mr. RECK. It is just a very quick comment. There is a slightly different perspective that I think is very helpful in looking at this, as well. Everyone here tends to be looking at dual use from the standpoint that it is going to be an additional cost. The mission manager wants to sit there and think about how much more of his money is going to be required to do that.

I think there is a very intriguing aspect, that is a leverage aspect. What we are talking about are dual-use applications here, where both people are bringing something to the table. When we collaborate with industry and with universities and with State and local governments, they bring intellectual resources to the table, and they bring cash and in-kind resources to the table. We end up doing more with the same amount of money.

And, in fact, as we are hit with budget pressures and we try to deal with level budgets and still accomplish missions, we find that we are going to be able to do what we thought we could not do before by working collaboratively with other people. I think there is a very positive aspect of this that needs to be communicated and needs to be put on the table.

Senator ROCKEFELLER. Are these other people from the private sector, the university sector, knocking on your door for this collaboration? Or do you have to go to them, because they do not believe that you really mean it?

Mr. RECK. We have to stimulate that, I think, at this point. I think that it is incumbent on us to do that. As Mary suggested, the wolves are at the door. We cannot do everything that we want to do, and we have to go out and seek that for two reasons: we do not have the resources and then, second, we have to demonstrate the relevance.

And so, for those two reasons alone, we are going out aggressively, setting up the workshops, developing the communication linkages, using the information infrastructure, establishing the collaborations, working with trade associations and organizations, and doing everything that we can to reach every sector of the community that would possibly overlap our technology capabilities and areas.

Senator ROCKEFELLER. Gentlemen, God bless you both.

This hearing is adjourned.

[Whereupon, at 12:15 p.m., the hearing was adjourned.]

APPENDIX

PREPARED STATEMENT OF DR. C.E. "TOM" VELEZ, FOUNDER, PRESIDENT, AND CHIEF EXECUTIVE OFFICER, CTA INC.

It is a pleasure for me to provide to you my observations on the important steps that need to be taken to expand the commercialization of space.

Other than geosynchronous communications applications, what has been called "commercial space" has simply been business as usual with the Government. A venture where the Government represents over 90 percent of the revenue base (e.g. commercial Titan) or provides the capital intensive satellite infrastructure (e.g., GPS), can hardly be called a commercial success.

I believe this is because market drivers do not exist today which overcome the difficulty of privately financing space systems. Space-based services and products are not available at affordable or attractive prices. Imagine trying to commercialize a "ride in space" on the shuttle; at the going rate of $200-600 million per flight (depending on whether you amortize the shuttle development cost), the cost per passenger would range from $2-10 million per ride. Further, at today's prices, transporting a single meal to the space station would cost $15,000!

Today, investors view the cost of space projects—typically in the hundred million to multi-billion dollar range—as prohibitive. Most space entrepreneurs spend over 80 percent of their time searching for seed capital, mainly because there have not been any financial successes yet. To compound the problem, space is fraught with the risk of launch failures, satellite failures, political instability, unproven markets, competition from new technologies, and competition from foreign governments.

One view is that without Government subsidy of systems such as NOAA satellites, LANDSAT and GPS, ventures to sell services and products based on space systems cannot be profitable. I disagree. I believe that if we consider the real costs experienced by the Government in systems development, including the impact of long development schedules and funding shifts during such periods, commercial viability of such ventures is possible. In the beginning, it would simply require lifecycle guarantees for data and/or service purchases by the Government at a price reflective of the real costs of system development.

What will happen then is that best commercial practices driven by competition for global market share will result in significantly lower development costs.

I believe it is time for the Government to ease out of the role of developer on those space systems which can be provided economically by industry, and instead become a reliable customer of that industry for essential non-classified products and services. There is, however, a continuing development role for the Government in support of access to low-cost launch services and technological advances critical to the maintenance of U.S. leadership in space.

The recent loss of LANDSAT 6 will inevitably lead to a data gap. CTA intends to respond with a low-cost, rapidly deployed, LIGHTSAT solution which will provide a subset of LANDSAT 6 data products. This plan will meet primary U.S. needs and maintain our existing worldwide customer base until LANDSAT 7 is available. Our plan exploits existing designs of LIGHTSATS and high performance military sensors adapted for commercial applications, in conjunction with existing ground systems and distribution channels.

A key issue for the success of this, and similar ventures, if it were to be strictly commercial, is the cost associated with launching satellites into low earth orbit. The expense of launching LIGHTSAT-type payloads into space today drives the entire cost of the space mission—so much so that commercial viability may hinge critically upon lowering launch costs.

A well publicized factor in the equation is the opportunity today to utilize existing Russian space assets at a very cost-effective price. We at CTA are attempting to work with the Russians to bring small launch vehicles into the United States for deployment of LEO systems. We are doing this in spite of the fact that we are also a domestic launch systems provider through our own subsidiary. I am convinced

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that low cost launches offer the U.S. space industry an opportunity to "kick start" a billion dollar LIGHTSAT industry which over time will create many new payload opportunities for all of us.

Previous administrations have encouraged a protectionist policy for the launch industry, but the world has changed dramatically, and I believe we will see more and more U.S. launch joint ventures with foreign partners. Rather than framing this as unfair competition with U.S. industry, I believe it is preferable to view it in a broader context of future new jobs and markets for the U.S. I am reminded of the NAFTA arguments. This also fits well with the president's stated goals of promoting use of private capital to promote economic development in Russia.

To put our qualifications for these proposals in perspective, CTA's space division launched its first LIGHTSAT in October 1985. Since then, we have designed, built, launched and successfully operated 19 satellites of increasing complexity and capability. Our most recent satellite—RADCAL-was launched in June 1993 on a scout. This satellite is operating nominally and was delivered in less than thirteen months from contract award.

The average weight of these LIGHTSATS has been approximately 240 pounds, built at an average cost of well under $10 million each, and with an average production rate of over two satellites per year. We currently have seven additional satellites in production, including what we believe to be the first geosynchronous commercial direct broadcast LIGHTSAT.

In summary, approvals for proposals such as the use of low cost launch assets and streamlined acquisition procedures for guaranteed multiyear purchases of data and/or services by the Government will go a long way to reversing the doldrums we are now experience in commercial space.

Thank you for the opportunity to provide my views before this Subcommittee.

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